Purification of nano-crystalline ultra-dispersed diamond to be employed as nanoprobes for cellular imaging

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Keywords: nanocrystalline, diamond, UDD, nanoprobe, imaging

Abstract

The development of novel nanoparticles for imaging living cells in vivo without harming or disrupting their intracellular molecular dynamics is an important area of nanotechnology that intersects Materials Science, Physics, Chemistry, and Biology. Nano-crystalline ultra-dispersed diamond (UDD) particles are photo stable, biocompatible, and can be tailored for a range of excitation and emission wavelengths. Purification of the powder is necessary in order to remove the non-diamond carbon components and other impurities surrounding the nano-diamond crystals. The effects of UV exposure in air and of heat treatment in H_2 and H atmosphere on the structure and properties of detonation UDD are investigated. The variation in the powder structure and properties after the exposure at different temperatures for variable periods is studied by TEM, X-ray photoelectron spectroscopy, visible and UV Raman spectroscopy, and Fourier transform infrared spectroscopy. The results show that it is possible to significantly increase the purity of the UDD powder by UV irradiation in air (Fig. 1 and Fig. 2). The role of oxygen and hydrogen radicals is discussed. A strong luminescence background is excited with the 514 nm laser line (Ar ion laser) during Raman spectroscopy experiments (Fig. 3). We aim to learn how to tailor the nanoparticle size, composition, and surface termination, particularly targeting for long-lived yellow-green-blue luminescence states, in preparation for subsequent in vivo studies.

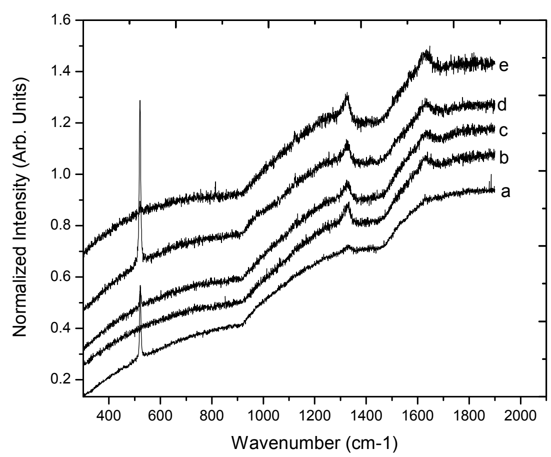
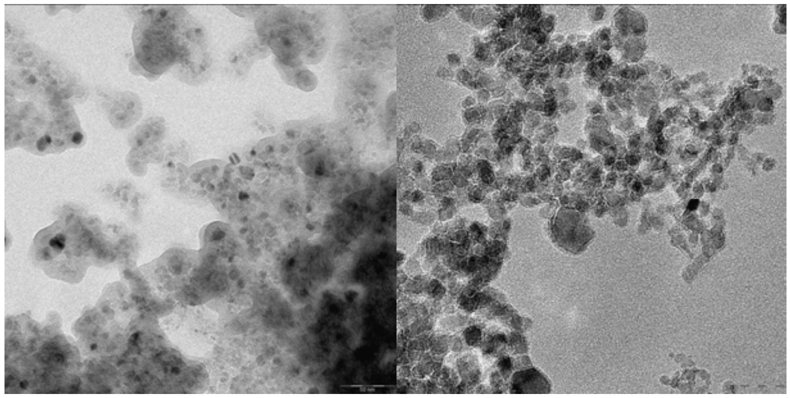


Figure 1. Visible Raman spectroscopy of the UDD that were treated with UVO, at naked eyes we can see how the diamond peak growths as the time of exposure increases. Here (a) is the powder not exposed, (b) after 1 hour of treatment, (c) after 5 hours, (d) after 15 hours and (e) after 45 hours.



50 nm ----------- 20 nm -----------

a. Original UDD powder b. Purified UDD powder

Figure 2. TEM image of diamond nanoparticles (UDD), before and after purification, showing their rounded shape and nanoscale size.

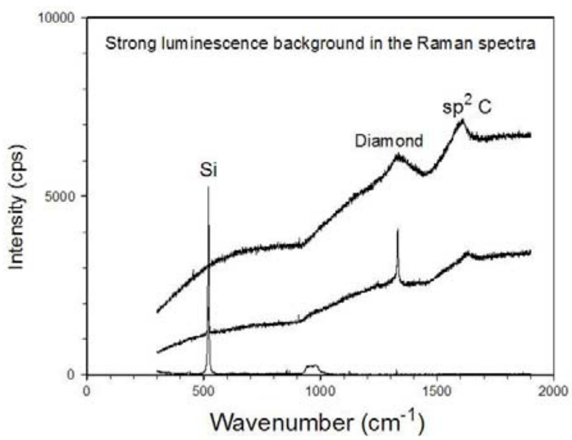


Figure 3. Strong luminescence background excited with the 514 nm laser line (Ar ion laser) during Raman spectroscopy experiments of different nanocrystalline diamond powders. The luminescence becomes stronger as the n-D particle size decreases, as indicated by the diamond band broadening. The dips in the spectra are artifacts of the CCD detector employed due to the fact that three spectral regions were collected and joined. Collecting the data with a PMT will give a smooth broad band with the Raman peaks on top. The Si spectrum taken under identical conditions is shown as reference.

Acknowledgements: Research supported by NASA (Grants NCC3-1034 and NGT5-40091; Cooperative Agreement NCC5-595), Department of Energy (Grant DE-FG02-01ER45868), and the UPR-Río Piedras FIPI (Grant 8-80-514).

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